CO2 abatement, competitiveness and leakage in the European cement industry under the EU ETS: Grandfathering vs. output-based allocation

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Abstract

A recurrent concern raised by the European GHG Emissions Trading System (ETS) is the fear of EU industry competitiveness loss: a loss in domestic production and a loss in profits. This paper analyses how production and profits in the European cement industry may depend upon allocation approaches. We analyse two contrasting allocation methods of free allowances. Under "grandfathering", the number of allowances a firm gets is independent of its current behaviour. Under "output-based allocation", it is proportional to its current production level. Whereas almost all the quantitative assessments of the EU ETS assume grandfathering, the real allocation methods used by Member States, notably because of the updating every five years and of the special provision for new plants and plant closings, stand somewhere between these two polar cases.

We study the impacts of these two polar allocation methods by linking a detailed trade model of homogeneous products with high transportation costs (GEO) with a bottom-up model of the cement industry (CEMSIM). The two allocation approaches have very different impacts on competitiveness and emissions abatements. Grandfathering 50% of past emissions to cement producers is enough to maintain aggregate profitability (EBITDA) at its business-as-usual level, but with significant production losses and CO_2 leakage. For an output-based allocation over 75% of historic unitary (tCO_2/tonne-cement) emissions, impact on production levels and EBITDA is insignificant, abatement in the EU is much lower but there is almost no leakage. Policy needs to recognise to what extent different allocation approaches may change the impacts of emissions trading, and adopt approaches accordingly.

Keywords

Grandfathering, Output-based allocation, competitiveness, leakage

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1. Introduction [1]

The European GHG Emissions Trading System (ETS) is the most important ETS worldwide and arguably the most important European climate change mitigation policy in place. Assessing the environmental effectiveness and economic efficiency of the EU ETS is therefore of the utmost importance. Furthermore, many other countries, including the US, have not implemented similar policies to date, so the EU ETS may impact European CO_2-intensive industry competitiveness.

However, the debate is blurred because wordings such as "competitive disadvantage", "competitive distortion" and "competitiveness" have very different meanings. Following Krugman (1994), one can even argue that at the macroeconomic level, the very notion of competitiveness is meaningless. However, for an industrial sector, the situation is different and these terms can basically be reduced to two interpretations:

1. a loss in domestic production, which in turn may induce leakage to imports from production in other parts of the world ("pollution havens");

2. a loss in profits, hence in stock value, of domestic firms.

It is essential to disentangle these two effects since, as we shall see, different allocation criteria would impact them in completely different – and often opposite - ways. Hence, in the present paper, we analyse two contrasted allocation methods. In the former, labelled "grandfathering" (GF), the number of free allowances a firm gets is independent of its current behaviour. As we demonstrate later, this assumption applies well to the US SO_2 trading system, but much less to the EU ETS.

In the latter, labelled "output-based allocation" (OB), firms receive allowances *proportional to* their current production level – sometimes known as *intensity-based allocation*. In its pure form, this allocation method is currently excluded by the Commission, because it amounts to an “ex-post” adjustment (allocation dependent upon behaviour during the same trading period), but it does incorporate some features of the real-word allocation method. Notably, repeated allocation over sequential periods gives potential for “updating” based on output or emissions in the previous period, which offers a weaker (deferred) form of output-based allocation, as detailed in section 2 below. The allocation methods used by Member States in phase 1 thus stands somewhere in between our two polar cases, and so are the methods allowed by the directive for phase 2.

Almost all the quantitative assessments of the EU ETS that have been recently published assume grandfathering, as defined above (Bernard et al., forthcoming; Criqui and Kitous, 2003; Klepper and Peterson, 2004 and 2005; Reilly and Paltsev, 2005). An exception is IEA (2004). As we shall see in our simulations, this assumption has a critical influence not only on competitiveness but also on the environmental impact of the ETS (emissions reductions in the EU and abroad).

We study the impacts of these allocation methods on the EU 27 cement industry, which represents around 10% of world emissions from the cement industry, through the CEMSIM-GEO model. GEO is a trade model we developed to deal with homogeneous products with high transportation costs (Demailly and Quirion, 2005a and 2005b). The world is divided into more than 7,000 areas, which allows us to compute transportation costs. In the new version of GEO we use here, we assume that a Cournot oligopoly competition takes place in every area among all the producers of the world, where demand is assumed linear.[2] This setting is inspired from Brander (1981) and Brander and Krugman (1983). Moreover, producers are subject to a capacity constraint.[3]

CEMSIM is a bottom-up model of the cement industry, developed by the IPTS (Szabo et al, 2003 and 2006). It pays particular attention to fuel and technology dynamics. Seven technologies are included, characterised by energy, material and labour consumptions, an investment cost and a set of retrofitting options.

We apply GEO to cement for three reasons. Firstly, GEO is particularly suited to the cement sector because transportation costs and capacity constraints are central to explaining international trade patterns of this homogeneous product. Secondly, cement is an important greenhouse gas emitter, due to cement consumption growth over the last decades and the very high carbon emissions per tonne, both from fuel combustion and from the process itself. The sector's emissions from fuel combustion represented 2.4% of global carbon emissions in 1994 (IEA, 1999). Adding process emissions, the sector reaches around 5% of global anthropogenic CO_2 emissions. Thirdly, the cement sector is potentially one of the most impacted by a climate policy: among twelve EU 15 industry sectors, non-metallic minerals – mostly cement – have the second-highest direct CO_2 emission/turnover ratio, just after power production (Quirion and Hourcade, 2004).

In section 2, we briefly describe how allowances are allocated in the EU ETS. Section 3 presents a simple theoretical model in order to explain the main differences between grandfathering and output-based allocation. Section 4 describes the applied model and section 5 describes the scenarios and provides the results of the simulations. Section 6 concludes.

2. Allowance allocation in the EU ETS

The most straightforward way of modelling an emission trading system (ETS) is to assume that firms covered by an ETS behave as if they were covered by an emission tax or auctioned emission allowances, i.e., that they factor the value of allowances into their marginal production decisions, irrespective of how many allowances they get for free. Such a behaviour is consistent with profit maximisation as long as the number of free allowances the firm gets is independent of its current behaviour (especially of its production level): freely allocated allowances have an opportunity cost, so it is rational to add them to the marginal production cost as though the firm had to buy them through an auction or on the market. Throughout the paper, we shall label "grandfathering" an allocation method in which the number of free allowances the firm gets is independent of its behaviour.

Under such an allocation, combined with profit maximisation, whether the allowances are auctioned or freely distributed does not impact production nor emissions, but only profits and stock value. Tietenberg (2002: 3) makes this case as follows:

"Whatever the initial allocation, the transferability of the permits allows them to ultimately flow to their highest-valued uses. Since those uses do not depend on the initial allocation, all initial allocations result in the same outcome and that outcome is cost-effective".

These assumptions have been used in most assessments of the EU ETS, e.g. by Bernard et al. (forthcoming); Klepper and Peterson (2004 and 2005); Reilly and Paltsev (2005)[4].

However, the assumption that the number of free allowances a firm gets is independent of its current behaviour applies well to the US SO_2 trading system, but much less to the EU ETS, for at least three reasons (Åhman et al., 2005; Schleich and Betz, 2005)[5]:

⇒ Allowances are first allocated for a three-year period (2005-07), and then every five years, taking into account new information. In particular, if a firm reduces its production, it may well receive fewer allowances in the next periods. In the extreme case of a plant closure, no allowance will be allocated in the next periods;

⇒ In all national allocation plans (NAPs), allowances are allocated for free to new entrants, although according to different formulae (Åhman et al., 2005). Furthermore, new entrants are defined extensively, including installations increasing their permitted production capacity;

⇒ All national allocation plans but two (Sweden and the Netherlands, cf. Åhman et al., 2005) state that if an installation is closed, it will stop receiving allowances, from the subsequent year and thereafter[6].

Compared to auctioning or grandfathering, all these features constitute an incentive for firms to increase their production level. Unfortunately, modelling the precise features of all 25 NAPs would be very difficult: the allocation methods differ across Member States, and the NAPs for 2008-12 are not decided yet. Instead we shall model two polar cases, knowing that the actual allocation method in the EU ETS stands somewhere in between:

⇒ Pure grandfathering (GF), as described above;

⇒ Output-based allocation (OB), under which firms receive an amount of allowances, proportional to their current production.

These two scenarios are identical to those tested in other policy contexts by Haites (2003 and Edwards and Hutton (2001).

3. Grandfathering vs. output-based allocation: the basic theory

A simple theoretical model will help to understand how the two allocation methods differ. Let us take a set of *N* homogeneous firms competing under Cournot competition with a linear demand curve on the goods market. These firms choose an output and an abatement level in order to maximise their profit:

$$\underset{q,ua}{Max}\,\pi = P(Q)\,q - q.c(ua) - P_{CO2}\,(e - gf - q.ob) \quad (1)$$

With:

$$e \equiv q\,(ue_0 - ua) \quad (2)$$

$$Q = \sum_N q \quad (3)$$

$$P(Q) = a - b.Q \quad (4)$$

where $P(Q)$ is the inverse demand, decreasing, Q the aggregate output, q a firm's output, c the marginal production cost, assumed constant with respect to production and increasing with ua (for unitary abatement), which is the abatement level per unit of output, P_{CO2} the allowance price, assumed exogenous[7], e the level of emissions per firm, gf the amount of allowances grandfathered (if any) to a firm, ob (for output-based) the amount of allowances distributed for each unit of output (if any), ue_0 the baseline unitary emission. $a > 0$ and $b > 0$ are the parameters of the demand curve.

The case of pure auctioning can be studied by setting both gf and ob to zero; grandfathering, by setting ob to zero; and output-based allocation, by setting gf to zero.

Profit maximisation leads to the following first-order conditions:

$$\frac{\partial \pi}{\partial ua} = 0 \Leftrightarrow c'(ua) = P_{CO2} \tag{5}$$

Equation (5) is the usual condition of equalisation of the marginal abatement cost to the price of CO_2, which is unaffected by the allocation method. This result is consistent with (and is indeed the basis of) Tietenberg's conclusion above.

$$\frac{\partial \pi}{\partial q} = 0 \Leftrightarrow P\left(Q\right) = c\left(ua\right) + b.q + P_{CO2}\left(ue_0 - ua - ob\right) \tag{6}$$

Summing (6) over the N firms and solving using (4) yields:

$$P = \frac{a + N.ec}{N+1} \tag{7}$$

$$Q = \frac{a-P}{b} \tag{8}$$

Where ec, the extended variable production cost, is defined as:

$$ec \equiv c\left(ua\right) + P_{CO2}\left(ue_0 - ua - ob\right) \tag{9}$$

From equations (6), (7) and (8), we can see that:

- ⇒ Under auctioning or grandfathering, i.e., if $ob = 0$, firms add the value of emissions per unit of output ($ue_0 - ua$) to their marginal production cost. Furthermore, the marginal production cost increases with abatement, which raises the output price further. To what extent these extra costs are passed on to consumers depends on the number of firms N.

- ⇒ gf does not influence the output price, nor the output level. This is because grandfathered allowances have an opportunity cost. This is consistent with Tietenberg's quotation above. However, from (1), compared to auctioning, grandfathering increases the profit level.

- ⇒ Compared to auctioning or grandfathering, output-based allowances (a higher ob) reduce the price level and increase the output. If the sector considered is neither a net buyer nor a net seller on the allowance market ($ue_0 - ua = ob$), then P rises above its business-as-usual level only in so far as the marginal production cost increases with abatement. If the sector considered is a net buyer of allowance ($ue_0 - ua > ob$), then firms add to their marginal production cost the value of the allowances they must buy ($ue_0 - ua - ob$), as in IEA (2004). If, conversely, the sector is a net allowance seller ($ue_0 - ua < ob$), output may rise compared to business as usual. At last, when ob tends to zero, the impact on P and Q tends to that of grandfathering or auctioning.

These conclusions are consistent with the theoretical models by Sterner and Höglund (2000; Fischer (2001); Gielen and al. (2002), except that we take the allowance price as exogenous, which is justified by the fact that the sector we study represents only a small share of the ETS (around 2% of total allowances). Otherwise, for a given overall level of emissions, output-based allocation implies a higher allowance price than grandfathering or auctioning: since unitary abatement is identical for a given allowance price (eq. 5) and output is higher under OB (eq. 7, 8 and 9), unitary abatement, and thus allowance price, must be higher under OB to obtain the same level of total abatement.

Because in these early models there is neither imperfect competition nor CO_2 leakage, OB leads to a higher cost, for a given abatement, than grandfathering. The inclusion of these two features may yield to a different conclusion, as demonstrated by Fischer and Fox (2005); Edwards and Hutton (2001) with general equilibrium models.

4. Presentation of CEMSIM-GEO

Cement is a product which is quite homogeneous throughout the world. The existence of different prices is mainly justified by the importance of transportation costs. Whereas a tonne of cement is sold around €80 at the exit of a plant in France, it costs €10 to transport it by road over 100km. The cost is much lower by sea: transporting cement from a harbour in East Asia to Marseille is the same as from Marseille to Lyon. Such a characteristic must be taken into account when assessing the impact of an asymmetric climate policy on the cement industry: whereas coastal regions could be severely impacted, inland ones seem to be relatively protected.

In GEO, the trade model we developed (Demailly and Quirion, 2005a and 2005b), cement is a homogeneous product: the firms of the 47 producing countries are assumed to manufacture perfectly substitutable products. The world is divided into more than 7,000 areas, as displayed in Figure 1, and up to

1,600 real sea harbours and more “land harbours” are represented, which allow us to compute realistic transportation costs.

In the new version of GEO we use here, we assume that a Cournot oligopoly competition takes place in every area among all the producers of the world. Producers compete on the market of an area given their extended variable production cost and their transportation cost from their plants to the market. Demand is assumed linear. This modelling is inspired by Brander (1981) and Brander and Krugman (1983). Moreover, producers are subject to a capacity constraint. When its capacity constraint is binding, a producer gives the priority to its domestic areas and sells its production in the most profitable areas. A cement firm may extend its available capacity to export by using plants located more deeply inside its territory, and consequently by increasing production cost through higher transportation costs. However, its exports are capped by its total capacity.

The use of the Cournot model instead of other competition representations (Bertrand, Stackelberg, limit price…) is not only justified by the support of the literature or its tractability, but also by the fact that it is compatible with the following quotations from cement manufacturers and analyst (OXERA, 2004):

“Cement is a local commodity market (…)– haulage costs are significant…, therefore [we] expect significant cost pass-through”

“Cement travels on water, not well on land… imports set the price anywhere close to water with a decent port facility…”

“As import prices often cap selling prices, margins will be squeezed as costs rise … we expect no change in current cement prices”

Indeed, let us take the example of a French inland area protected by transportation costs where no foreign firm is cost-competitive enough to be part of the equilibrium in this area. Demand is linear: $P = a - b \cdot Q$. The *N* identical French firms, with an extended variable production cost *ec*, equally share the market where the price *P* is given by: $P = \frac{a + N \cdot ec}{N + 1}$ (cf. above, section 3). A rise in *ec* leads to a *N*/(*N*+1) cost pass-through.

Let us now assume that *N*' firms of a given foreign country, with a variable production cost *c*' and a transportation cost *tc*, are cost-competitive enough to be part of the equilibrium on the market of a French coastal area. Price is given by: $P = \frac{a + N \cdot ec + N' \cdot \left(c' + tc\right)}{N + N' + 1}$. A rise in *ec* leads to a *N*/(*N*+*N*'+1) cost pass-through. The profit margin of French firms in this area is much more impacted than in the previous case.

The inland case corresponds to the first quotation above, the coastal case to the second and third ones.

CEMSIM is a bottom-up model of the cement industry, developed by the IPTS (Szabo and al, 2003 and 2006). It pays particular attention to fuel and technology dynamics. Seven technologies are included, characterised by energy, material and labour consumptions, an investment cost and a set of retrofitting options. The technologies considered in CEMSIM are already used on a large scale. Assuming no large-scale commercial application in a near future, the model does not take into account emerging technologies like mineral polymers, which could lead to radical emissions abatements (Prebay et al, 2006). We modified the original CEMSIM model to introduce more flexibility in the content of clinker – the carbon intensive intermediary product – in cement and in the choice of non-primary fuels, following discussions with French cement industrials.

We use the CEMSIM database on consumption, production capacity and energy demand, energy prices from the POLES model developed by the LEPII-EPE as well as cement bilateral trade data form OECD to calibrate the CEMSIM-GEO model, which is then recursively run with a yearly step.

Given the trade and technological details of CEMSIM-GEO, it is - for tractability's sake - a partial equilibrium model. Therefore we neglect the macroeconomic feedbacks, such as possible changes in GDP or exchange rates , but these impacts must be very soft – see, for example (IPCC, 2001) for GDP impacts. Furthermore, we do not explicitly model the substitutions between cement and other building materials, but since all the CO_2 intensive industries are covered by the EU ETS, substitutions should be limited. As a consequence, it does not seem injudicious to work in partial equilibrium.

We highlight the fact that, in GEO, cement is assumed to be homogeneous throughout the world: we neglect product quality or differentiation as a trade determinant. We calibrate non-transport barriers to match real bilateral trade data, assuming that, as soon as an exporter is competitive enough to export 1kg of cement to the harbour of a country, the only barrier to trade it faces to export more and more deeply inside this country is road transportation cost. However, many more barriers seem to exist in real cement trade. Foreign exporters cannot build up supply networks overnight. EU firms have the ability to keep the production of “aggressive” foreign producers out of home markets, for example by restricting their access to port facilities by occupying them. EU firms, which are highly concentrated and have developed their activities in non-EU countries, have the ability to keep imports out of home markets through collusive behaviours (EC, 2000). These features lead to overestimation of the trade impacts of climate policies. Moreover, if the one-stage Cournot model is of interest notably for addressing the cost pass-through issue, its ability to provide quantitative results is more controversial. We also stress that the quantification of some technical flexibility in CEMSIM (clinker ratio, retrofitting, and fuel choice) is very difficult. As a consequence, whereas our qualitative results are robust, our quantitative results should be considered very cautiously.

5. Simulations and results

In the next sections we present, for various scenarios, the results for 2008-2012[8] of some model outputs: cement production cost, prices, consumption, production, EBITDA and CO_2 emissions in EU27.

In the first set of scenarios, an EU27 ETS is implemented with allowances grandfathered. These scenarios are the “GF” scenarios. The scenario with firms being grandfathered 90% of their emissions in 2004 is the GF 90% scenario. This is our central GF scenario. Most of the model outputs under GF 90% do not depend on the amount of allowances allocated. When presenting such an output, to highlight this fact, we label this scenario "GF" instead of "GF 90%".

In the second set of scenarios, a firm's allocation is assumed to be proportional to its current cement production. These scenarios are the **"OB" scenarios.** In our central OB scenario, the output-based allocation of allowances is assumed to represent, for every firm, 90% of its 2004 emissions per tonne of cement (unitary emissions). This is the **"OB 90%" scenario**.

For the 2005-2007 period, the CO_2 price is modelled at an average of €20/tCO_2, close to the average value observed in 2005. Then, we make different assumptions for the CO_2 price between 2008 and 2012: from 10 to €50/tCO_2.

According to the last observations on the EU electricity market and to the emerging windfall profits debate in the EU, we assume that power generators have the ability to pass on to electricity prices 100% of their extended cost rise. For convenience's sake, this rise in a given country equals the CO_2 price multiplied by the national unitary emission of the power sector, whatever is the allocation method for the cement industry – as if the allowances in the electricity sector were always grandfathered.

For simplicity, we assume that non EU27 countries do not implement any climate policy, which leads to an overestimation of trade impacts and CO_2 leakage.

Some of the insights, especially under OB 90%, do not depend only on the CO_2 price but also on the amount of allowances allocated, so we made some sensitivity tests. However, we will present them only for the model outputs we judge the most important when studying the impacts on competitiveness of climate policies: production and EBITDA.

Under the **Business-as-Usual scenario** (BaU), no climate policy is implemented.

We stress that the comparison between the two central scenarios, OB 90% and GF 90%, should be made cautiously, because nothing guarantees that they lead to the same environmental improvement. It is even more delicate to compare the OB and GF scenarios with the same CO_2 price assumption, because these systems, if implemented also for other sectors in the EUETS, would lead to different prices (cf. section 3 above).

5.1. Cost-competitiveness

We label "extended variable production cost", or simply "extended cost", the cost with which firms compete on world cement markets, minus transportation costs, expressed in euro per tonne of cement. This determines the cost-competitiveness of firms.

(a) Grandfathering (GF).

As explained previously, under GF, the extended cost of EU cement manufacturers is defined by:

Extended cost = variable production cost + CO_2 opportunity cost,

CO_2 opportunity cost = CO_2 price * emission per tonne of cement (unitary emission).

Figure 2 shows how the opportunity cost increases with the CO_2 price. The rise is less than proportional. When the CO_2 price increases, cement producers are pushed to reduce their unitary emission by (1) diminishing the clinker content of cement – clinker being the CO_2-intensive intermediary product in cement production- – (2) switching from high to low carbon intensive fuels, (3) using more energy-efficient technologies. In 2008-2012, however, the reduction in unitary emission is mostly due to the decrease in the clinker rate in cement (-10% for €20/tCO_2). This decrease is provoked not only by the rise in the extended cost of clinker – due to the opportunity cost of emission, the increase in electricity prices and the use of more expensive low-carbon fuels – but also to the drop in the consumption and price of added materials, the non-clinker materials in cement, due to significant cement production losses, as we will see below[9]. Decompositions of the extended cost under BaU and GF 20 are provided in Figure 3, mixing the different technologies and fuel sources.

For €20/tCO_2, the extended cost rises by €14 per tonne of cement. This rise not only leads EU firms to reduce their output but also impacts their cost-competitiveness compared with that of foreign firms. In GEO, where road transportation cost is the only barrier to trade for exporters, this rise considerably facilitates the penetration of foreign cement into EU markets. Indeed, in the EU, €14/t allows an increase in the transport of cement by road by around 200km.

These results, as well as the following except EBITDA, are independent of the amount of GF allowances allocated.

(b) Output-based (OB) allocation

Under OB, the extended cost is defined by:

Extended cost = variable production cost + CO_2 price*(unitary emission - OB allowance)

We observe in Figure 2 that, according to CEMSIM-GEO, technical flexibility allows EU producers to decrease their unitary emission to 90% of their 2004 unitary emission for €20/tCO_2. It guarantees that the amount of output-based allowances allocated covers their emissions: they are neither buyer nor seller on the CO_2 market, and their extended cost simply equals their variable production cost.

Whereas firms buy some emission allowances for lower CO_2 prices, from €30/tCO_2, the average unitary emission in the EU is lower than the amount of allowances allocated per tonne of cement. Cement manufacturers become sellers on the CO_2 market, which supposes that there are buyers like the power suppliers. Therefore, although the EU variable production cost rises, its extended cost slightly decreases.

Obviously, this result depends on the allocation per tonne of cement: for a decreasing allocation, results tend to get closer to the GF case. However, according to the sensitivity test we made, we may consider that extended cost of EU producers is not highly impacted under OB for amounts of output-based allowances over 75% of the 2004 unitary emission: the expected[10] rise remains below 10%.

To underline this point, whereas the extended cost, and therefore the cost-competitiveness of EU firms, is highly impacted under GF allocation, it is not under OB for an output-based allocation, provided the allocation factor is over 75% of 2004 unitary emissions.

5.2. Prices

(a) Grandfathering (GF)

The results in Figure 4 show that, under GF, the average price applied by EU firms in their countries of origin increases significantly, following the rise of their extended cost. The cost pass-through is limited by oligopolistic competition and by international pressure: on average 75% of the extended cost rise is passed on to consumers. Around half of this limitation is due to oligopolistic competition, the other half to international pressure.

However, if the margin over the extended cost tends to decrease, the margin over the variable production cost increases.

(b) Output-based (OB) allocation

As shown previously, the extended cost of EU firms under OB 90% is not significantly impacted. Figure 4 shows, unsurprisingly, that the EU domestic price presents the same evolution. However, if the margin over the extended cost remains quasi constant, the margin over the variable production cost decreases slightly because the latter increases.

Obviously, these results depend on the amount of allowances allocated per tonne of cement. But, according to sensitivity tests, cement prices are not highly impacted as long as the amount of allowances per tonne of cement is over 75% of the 2004 unitary emission: the expected rise of cement prices remains below 5%.

To sum up, the EU domestic price and the margin over the variable production cost increase very significantly under GF. Under OB, for output-based allocation over 75% of 2004 unitary emission, they are weakly impacted.

5.3. Consumption, production and trade

(a) Grandfathering (GF)

As we have seen, the impact of GF on the cement price in the EU is very significant. However, because of the low elasticity price of demand (0.2), consumption is not highly affected: it drops by 3% for €20/tCO_2. Should the elasticity be higher – and it could be, especially in the mid–long term - so would be the impact on consumption.

However, the cost-competitiveness drop of EU producers heavily impacts EU cement trade flows (Figure 5). Under BaU (no ETS), EU countries on average import 11% of their cement consumed, 75% of these imports coming from other EU countries. At a carbon price of €20/tCO_2, on average, EU countries import 18% of their consumption, of which 75% comes from non-EU countries. EU exports (not displayed here) are halved and focus mainly on other EU countries - 90% of exports vs. 70% in BaU.

Obviously, results vary a great deal between countries and the aggregate results underplay the regional dimension within Europe. In the countries with high rates of import from non-EU countries before the implementation of a climate policy, imports have already deeply penetrated their territory.

Therefore, they are less protected by transportation costs and are more sensitive than countries with low rates of non-EU imports. The trade impact also depends on the size and location of the country, and the location of its population (due to transport costs, inland countries or large countries with population living mostly inland are proportionally less impacted than the small ones near the coast) and on its extended cost increase.

Therefore, whereas the production of the EU cement industry decreases in average by 15% for a €20/tCO_2 price, Austrian production almost maintains the same level, while Spanish production drops by almost 20%. On the one hand, Austria does not share borders with non-EU countries, does not have sea harbour facilities and imports very little cement from non-EU countries before the implementation of the ETS. On the other hand, Spain is a relatively large country but has a lot of sea harbours and imported in 2004 almost 20% of its cement consumption, mainly from non-EU countries.

We again emphasise some caveats of our trade modelling which lead to an overestimation of trade impact of climate policies: we neglect product quality or differentiation as a trade determinant, and non-transport barriers to trade which prevents foreign producers from increasing their exports, such as the difficulties in building a commercial network or the ability of EU firms to keep imports away out of home markets. Moreover, if the one-stage Cournot model is of interest notably for addressing the cost pass-through issue, its ability to provide quantitative results is more controversial. Finally, cement firms tend to be multinational firms, a characteristic GEO is not perfectly designed to cope with. Hence, cement imported from non-EU countries does not necessarily come from non-EU firms.

In conclusion, whereas the qualitative results are robust and allow comparison between the different scenarios, our quantitative results should be considered very cautiously.

(b) Output-based (OB) allocation

In sharp contrast, under OB 90%, EU consumption and imports are insignificantly impacted (Figure 5). This conclusion also holds for exports (not displayed here). However this does not hold for much tighter OB allocations (Figure 6). For allocation below 75% of 2004 unitary emission, the expected drop in production becomes significant (above 5%).

To sum up, whereas the impact on consumption is small because of the very low elasticity price of demand (and insignificant under OB), the impact on net import and production is great under GF, and the protection afforded by OB allocation declines if the allocation is under 75% of 2004 unitary emissions.

5.4. Operating profitability (EBITDA) [11]

(a) Grandfathering (GF)

Under GF, EU firms see their production decreasing and their margin over variable production cost increasing with CO_2 prices. These facts have opposite effects on their EBITDA from cement sales, the EBITDA on cement.

EBITDA on cement = $\sum_{\text{World areas}}$ (Price - Variable cost - Transportation cost)*Production

As we may see in Figure 7, the EBITDA on cement increases with low CO_2 prices and then decreases.

The net profit realised on the emission market, or simply the "profit on emission", is given by:

Profit on emission = (GF allocation – CO2 emission)*CO_2 price

Note that this is the only output of the model presented here which depends on the volume of GF allocation. For a GF allocation equal to 90% of historic emissions, cement manufacturers emit less than their allocation, because their production and their unitary emission drop enough for all the CO_2 prices tested. They are thus sellers on the CO_2 market, so their profit on emission is positive. Their emissions decrease and their profit on emission increases with rising CO_2 prices. As a result, the total EBITDA increases significantly with CO_2 prices, as does the share of profit arising from emission sales.

Obviously, this depends strongly on the amount of GF allowance allocated (Figures 8 and 9). If granted allowances equal to 50% of 2004 emissions, EU cement producers are significant buyers of CO_2 emission allowances but this remains more than offset by the value of the higher prices, and their EBITDA still rises; however, at allocations below this, they lose.

Once again, we stress that these aggregate results underplay the regional dimension within Europe. Whereas the EU EBITDA increases by 20% under GF 90% for a €20/tCO_2 price, Austrian EBITDA increases by around 30% and makes no profit on emissions - because its production is almost not impacted – while the Spanish cement industry - whose production is largely impacted - does increase its EBITDA by around 10%, thanks to allowances sales. For an allocation of 50% of 2004 emissions, Austrian cement producers keep on benefiting from the system, whereas the Spanish lose.

(b) Output-based (OB) allocation

As observed before, the margin over variable production cost decreases under OB. As displayed in Figure 7, there is little impact on EBITDA at low CO_2 prices, but for high prices, in spite of the slight production rise we have observed, EBITDA on *cement* decreases. As we have already seen, EU27 cement manufacturers turn out to be neither seller nor buyer of allowances for €20/tCO_2, but for higher CO_2 prices, they become sellers and profit on emissions sales:

Profit on emissions = (OB allocation - unitary emission)*production*CO_2 price

This is positive and increases with price because they sell more and at higher value. The aggregate impact on EBITDA is weak under OB 90%, even for high CO_2 prices.

Obviously, this conclusion about EBITDA depends on the amount of OB allowances allocated, which impacts both the profit on emissions and the EBITDA on cement[12]. Figure 10 indicates that, for allocation over 75% of 2004 unitary emission, our qualitative conclusion remains valid: the expected EBITDA drop is less than 5%.

To sum up, under GF and for allocations over 50% of past emissions, the EU EBITDA increases. Under 50%, it decreases. It is not highly impacted under OB as long as the amount of output-based allowances allocated is over 75% of 2004 unitary emission.

5.5. CO_2 emissions

(a) Grandfathering (GF)

Under GF, the drop in EU CO_2 emissions by the cement industry is very important: -25% for €20/tCO_2. Half of this drop is due to the decrease in unitary emission, the other half to the production drop (mostly the rise of net imports). This explains the very important carbon leakage rate[13] observed in Figure 11: around 50%. It means that half of the emissions reduction made inside EU is offset by an emissions rise outside.

We stress that not only is our trade representation (no product differentiation, focus on transport, no inertia in trade…) responsible for this important leakage around 2010, but so, also is the technical inertia: leakage decreases as time goes by with the introduction of more carbon-efficient techniques. Furthermore, the reader should keep in mind that we assume no climate policy outside the EU which explains a part of this high leakage rate.

(b) Output-based (OB) allocation

Under OB 90%, there is no significant production drop. The emissions reduction is only due to the improvement of the carbon efficiency of the EU cement industry. Therefore, for €20/tCO_2, it is halved compared with GF but the leakage rate is much smaller, around 9%, and decreases with high prices (Figure 11). Finally, for a given CO_2 price, world emissions reductions are almost similar under GF and OB90% - slightly higher under GF.

Again we stress that some results depend on the OB allocation: the tighter the allocation, the closer are the EU emissions reductions and carbon leakage to the GF scenarios.

To sum up, under GF, the huge emissions drop is partially offset by an important carbon leakage. Under OB, for generous allocations, the drop is much weaker and so is the leakage. The tighter the allocation, the closer are the EU emissions reductions and carbon leakage to GF. For every GF or OB scenarios, world emissions reductions turn out to be almost similar.

6. Conclusion

We have seen that the allowance allocation system of the EU ETS is neither grandfathering nor output-based allocation. But is it - and will it be in phase 2 - closer to the former or to the latter? This issue turns out to be a crucial one.

If the allowance allocation system is similar to grandfathering, EU cement producers (and many other firms also) will *in aggregate* benefit from a significant rise in their EBITDA, but lose market share to imports. Indeed, our simulations indicate that, whatever the allowance price, grandfathering 50% of past emissions to cement producers is enough to maintain their EBITDA to the business-as-usual level. Given that the Directive prevents Member States from auctioning more than 10% of the allowances for 2008-2012, and that the analyses of National Allocation Plans for 2005-07 show that industry has benefited from an allocation level close to BaU (Reilly and Paltsev, 2005; Schleich and Betz, 2005), cement producers will certainly receive more than 50% of their past emissions in the next generation of NAPs. However, our simulations also indicate a significant production loss and CO_2 leakage rate under grandfathering. As a consequence, although CO_2 emissions reductions are high under grandfathering in EU27 (around -25% for €20 per tonne of CO_2), about one half of this drop is compensated by a rise in emissions elsewhere.

If, conversely, the allowance allocation system is similar to output-based allocation for an allowance allocation ratio of 90% of historic unitary emissions, neither the production level nor the EBITDA is significantly impacted, even for a very high CO_2 price (€50 per tonne). Only if the allocation ratio were to drop below 75% of historic unitary emissions (a very unlikely policy choice) would competitiveness impacts (on production and EBITDA) be severe (above 5%). For any allocation ratio, abatement is reduced compared to auctioning or grandfathering, but so is leakage, and finally world emissions are almost similar.

Finally the allocation method - notably the updating criteria, the treatment of new entrants and the closure rules – turns out to be a variable of importance to determine the competitiveness impacts and the CO_2 emissions reduction achieved at the world level under the EU ETS.

Three important caveats are in order:

- First, despite the high level of regional disaggregation and incorporation of transport costs and port facilities in the GEO model, modelling trade impacts – and therefore the carbon leakage of climate policies - is still difficult, particularly over a relatively short period such as 2008-12. Notably because the explicit representation of some non-transport barriers to trade - like the ability of EU firms to keep imports out of from "home" markets through collusive behaviours or anti-competitive practices – is very difficult. Thus though the *qualitative* results are robust, the *quantitative* ones should be considered very cautiously.

- Second, the allowance price depends on the allocation method, not in the cement sector, but in the whole set of sectors covered by the EU ETS, especially power production. For a given emissions cap (or amount of allowances allocated), the allowance price would be higher under output-based allocation than under grandfathering.

- Third, implementing output-based allocation in the cement sector raises a difficult dilemma, due to the fact that 90% of cement emissions occur during the production of cement's main input, clinker, and that lowering the proportion of clinker in cement is one of the main means of cutting CO_2 emissions. If allowances are allocated in proportion to cement production, a producer may import clinker to make cement in Europe in order to receive free allowances and sell them. Leakage would then not be addressed. Alternatively, if allowances are allocated in proportion to clinker production, the incentive to reduce the clinker rate in cement vanishes, and so does a large part of CO_2 abatement. This problem is not taken into account in our simulations, since we model only trade in cement, not in clinker.

Ultimately, there exist at least one other means to address the competitiveness problem, other than free allocation of allowances. A tax or auctioned allowances with a border-tax adjustment as assessed in Demailly and Quirion (2005a and 2005b) offers the best of both worlds: compared to grandfathering, it prevents leakage, and compared to output-based allocation, it induces consumers to take into account the CO_2-intensity of the different building materials in their decisions, and does not suffer from the above-mentioned clinker dilemma.

Notes

[1] The present analysis has benefited from a deep collaboration with the Institute for Prospective Technological Studies (IPTS – Joint Research Centre – European Commission). Our analysis is partly based on the world cement model CEMSIM developed by L. Szabo, I. Hidalgo, J. C. Ciscar, A. Soria and P. Russ, from the IPTS. We thank them and the IPTS for the explanations on the model, for the free access to a world cement industry database compatible with the model structure and for having hosted one of us at the IPTS for two months. We also thank an anonymous referee, Michael Grubb, Karsten Neuhoff, Neil Walker, Peter Zapfel and participants at two meetings organised by Climate Strategies in Oxford and London for their comments, as well as Françoise Le Gallo for providing data on international cement trade.

[2] See Smale, this Volume, for explanation and discussion.

[3] In this paper, the capacity constraint is fixed: since we do not run the model beyond 2012, endogenising investment as in Demailly and Quirion (2005a and 2005b) would not make a significant difference.

[4] The authors are aware of this limitation and write (Reilly and Paltsev, 2005: 11) "we also cannot estimate the potential distortionary effects of non-lump sum distribution of some of the permits (those that under some countries' NAPs are retained for new entrants)."

[5] Furthermore, the assumption of profit maximisation may also be challenged: some managers may be reluctant to reduce production in order to sell allowances and increase the profit level, and use their information advantage over shareholders to maintain production above the profit-maximising level, as in Baumol (1962).

[6] Apart from if a firm closes an installation and opens a new one in the same Member State, it may retain these allowances, but then will not get allowances for the new installation.

[7] In this model and in the rest of the present paper, we assume that the considered sector is too small to influence the allowance price. Indeed, it represents around 2% of the allowances allocated in the EU ETS.

[8] More precisely, the figure presented for a given output variable in a given scenario is the average value of the output variable between 2008 and 2012.

[9] For further details on technological evolutions, see Demailly and Quirion (2005a), where the decreases in added materials prices due to production losses are not taken into account.

[10] To calculate the expected impact of a policy with an uncertain CO_2 price, we give a probability (a weight) to every price tested. We assume that probabilities are distributed according to a Gaussian curve centred at €25/tCO_2 – the

average price of 2008 forwards from the beginning of 2006 – and that the probability that price is between €15 and €35 equals 50%.

[11] Earning Before Interest, Tax, Debt and Amortisation

[12] The lower it is, the lower is the production and the higher is the margin on production cost, so that the effect on the EBITDA cement is not trivial, as under GF. Conversely, the lower is the OB allocation, the lower is the profit on emission.

[13] Leakage rate = increase in non EU27 emissions / decrease in EU27 emissions.

Figures

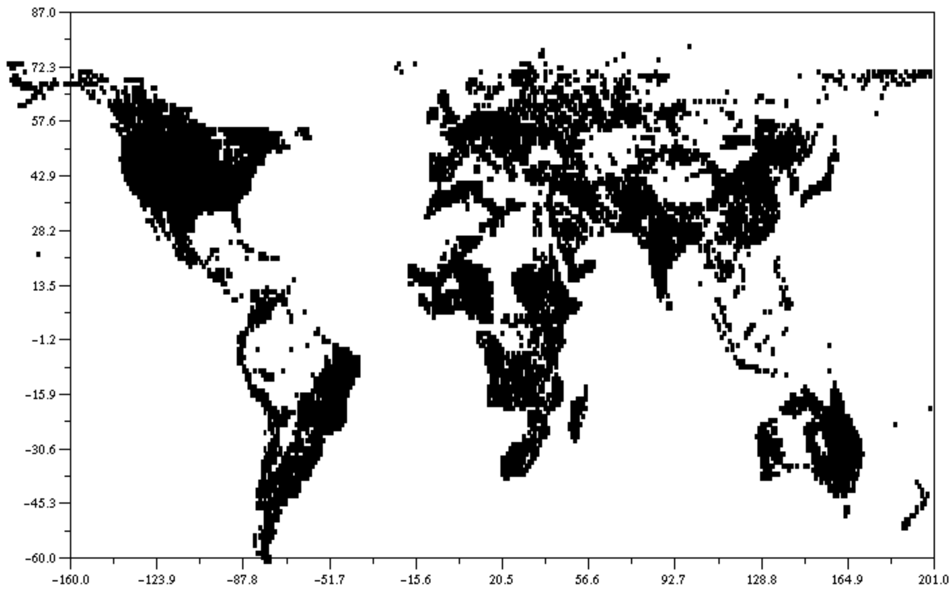

Figure 1: Areas of GEO

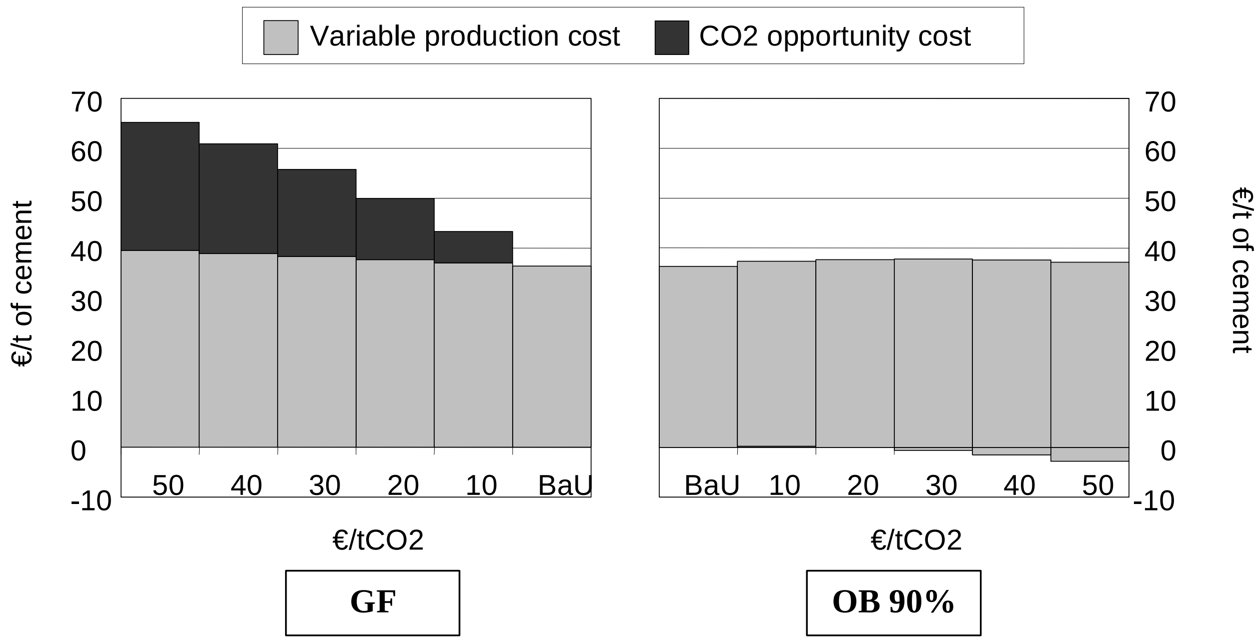

Figure 2: GF / OB 90% - EU27 extended cost

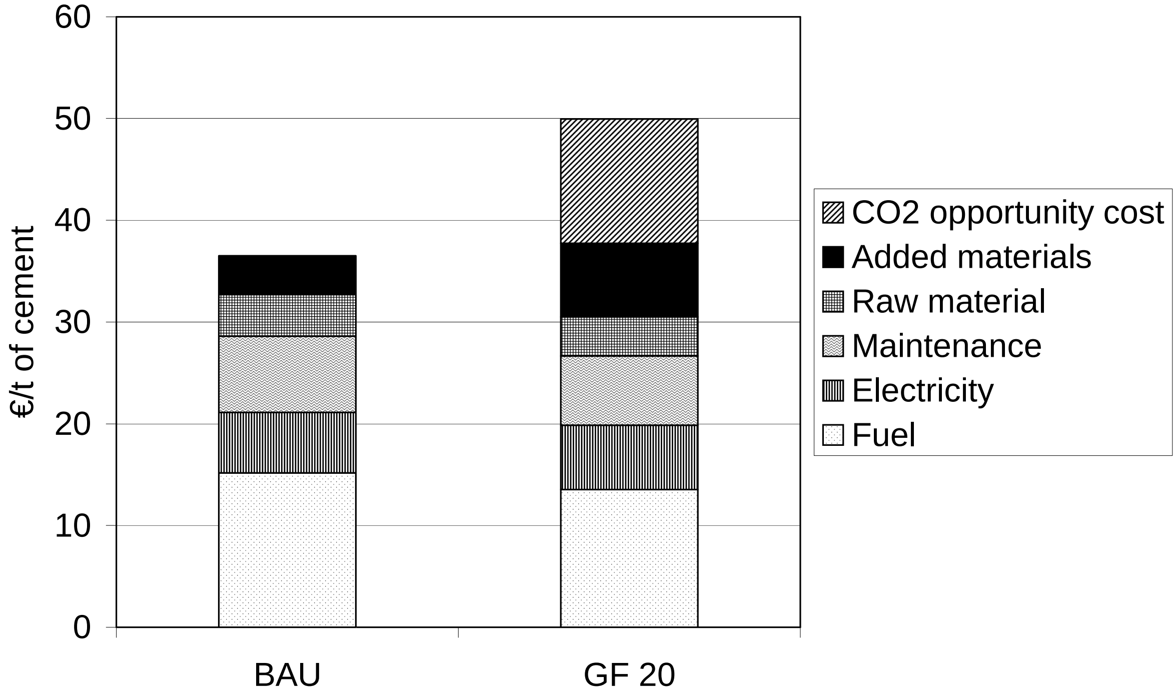

Figure 3: GF – structure of the EU27 extended cost

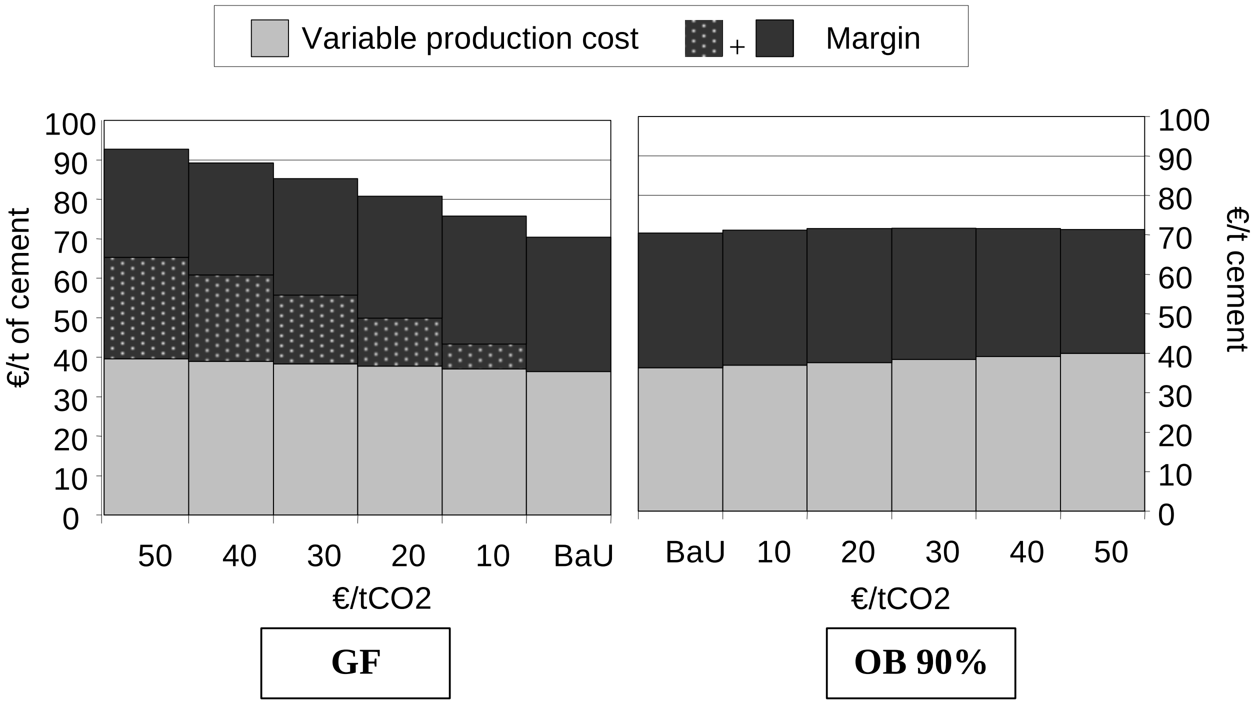

Figure 4: GF / OB 90% - EU27 price and margin

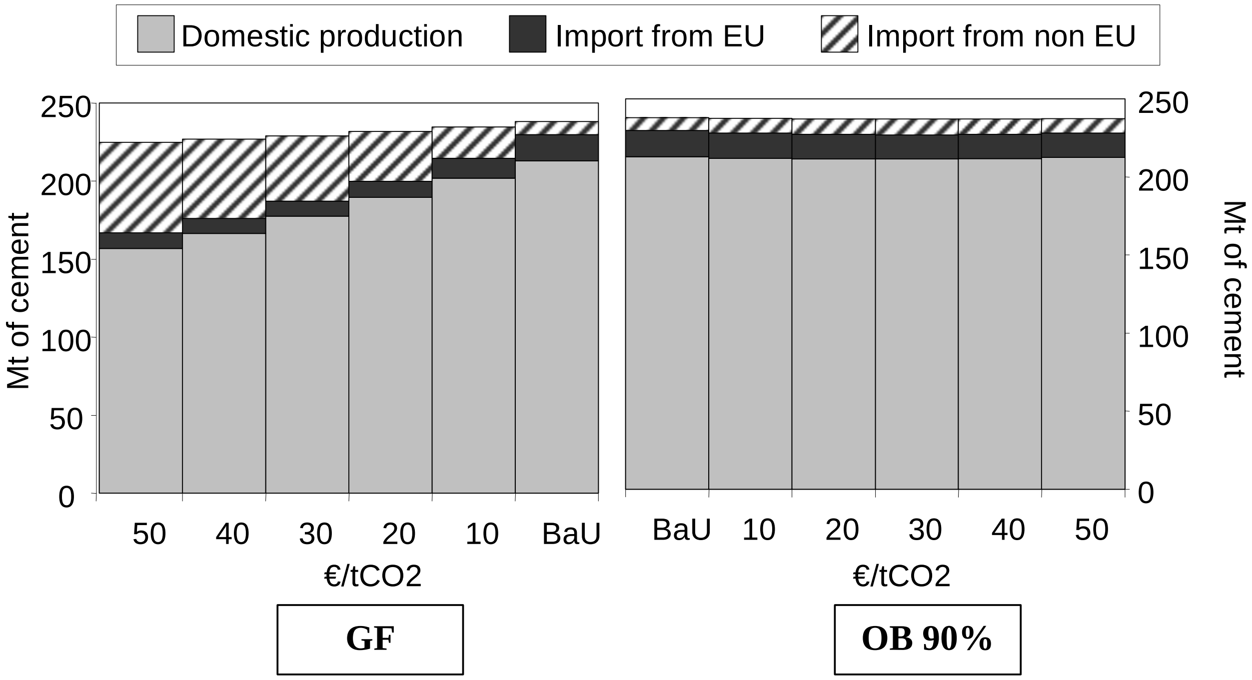

Figure 5: GF / OB 90% - EU27 consumption and trade

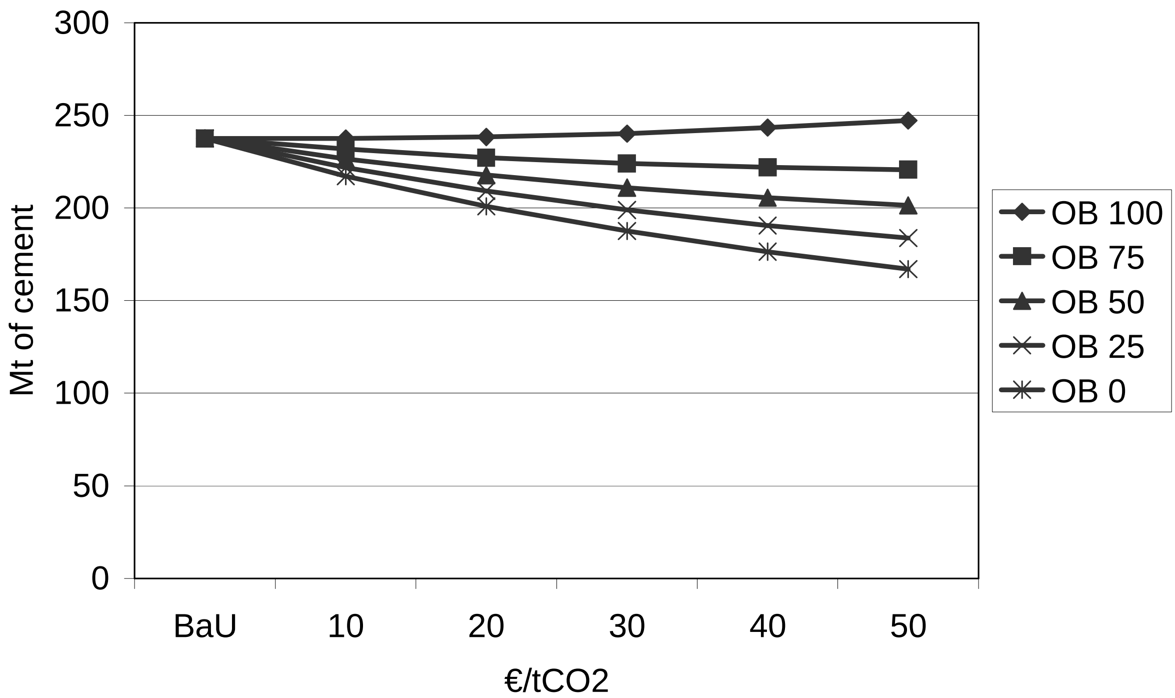

Figure 6: OB - EU27 production

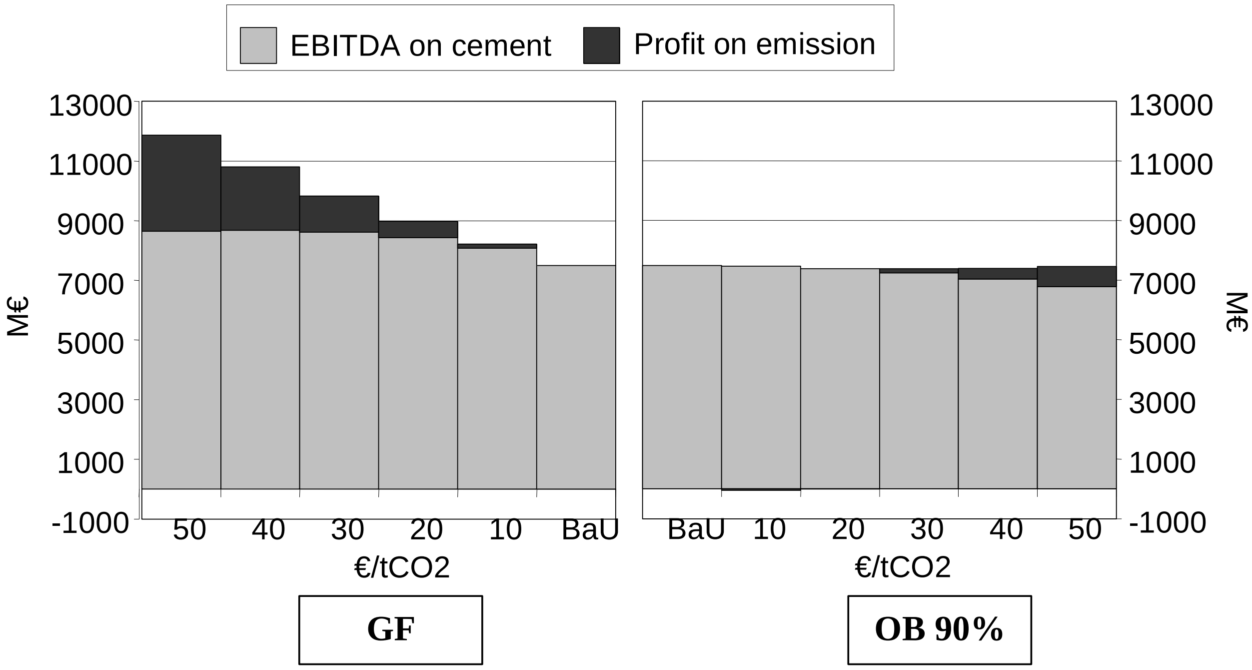

Figure 7: GF 90% / OB 90% - EU27 EBITDA

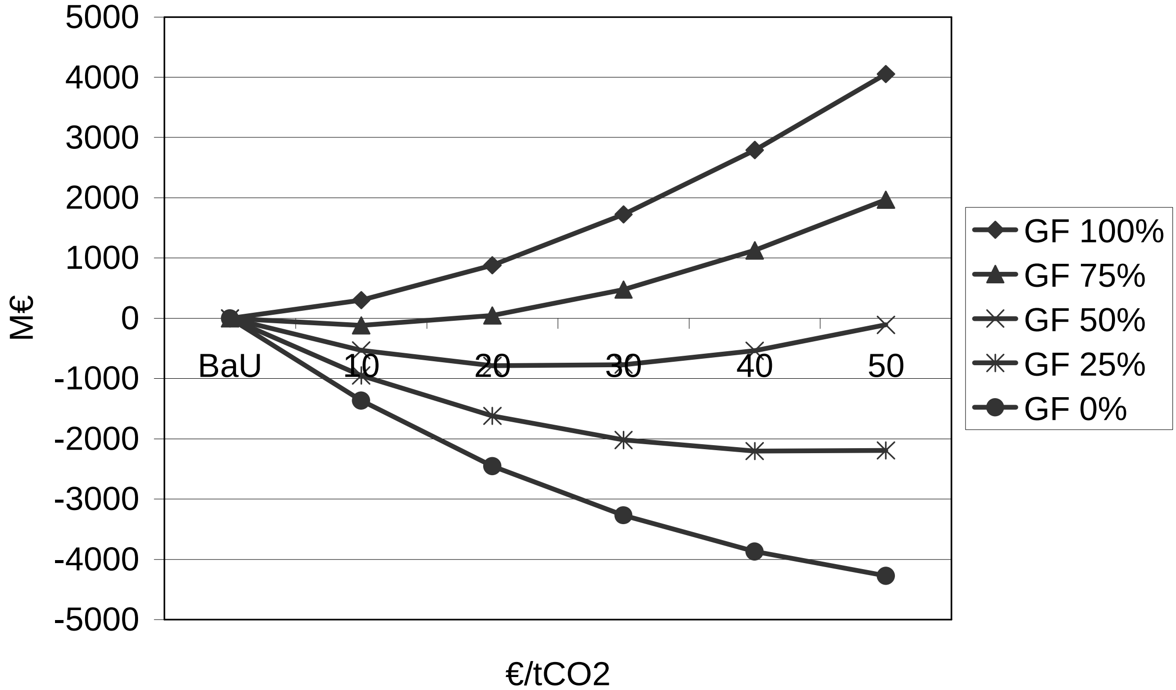

Figure 8: GF - EU27 profit on emission

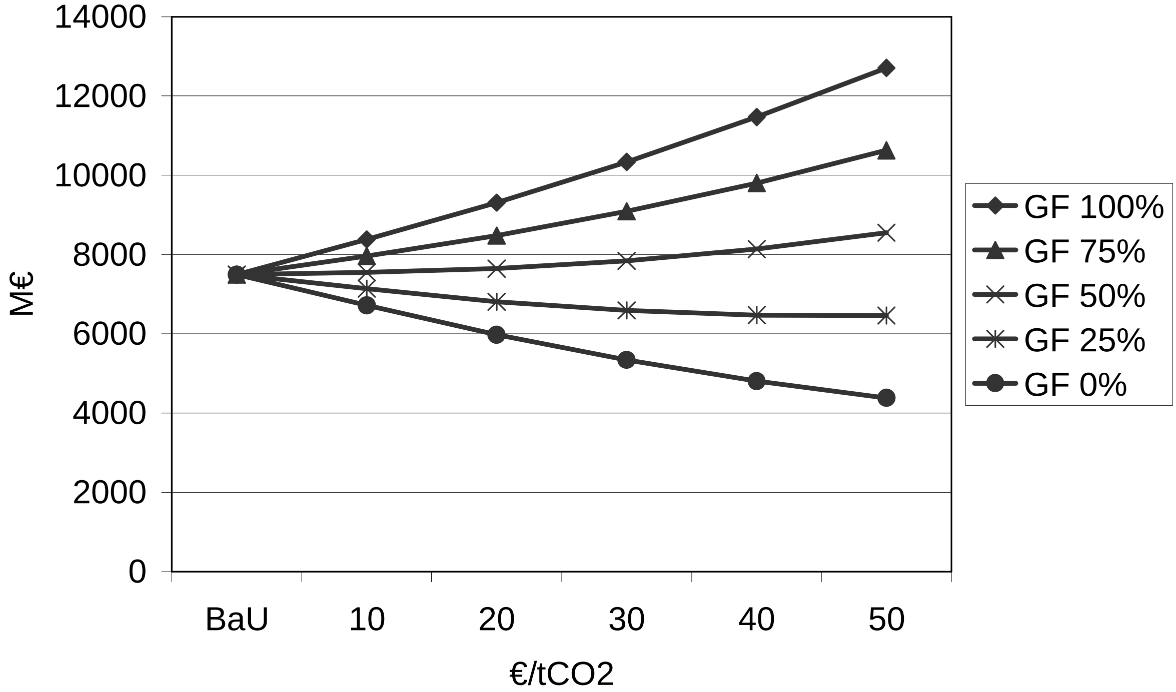

Figure 9: GF - EU27 EBITDA

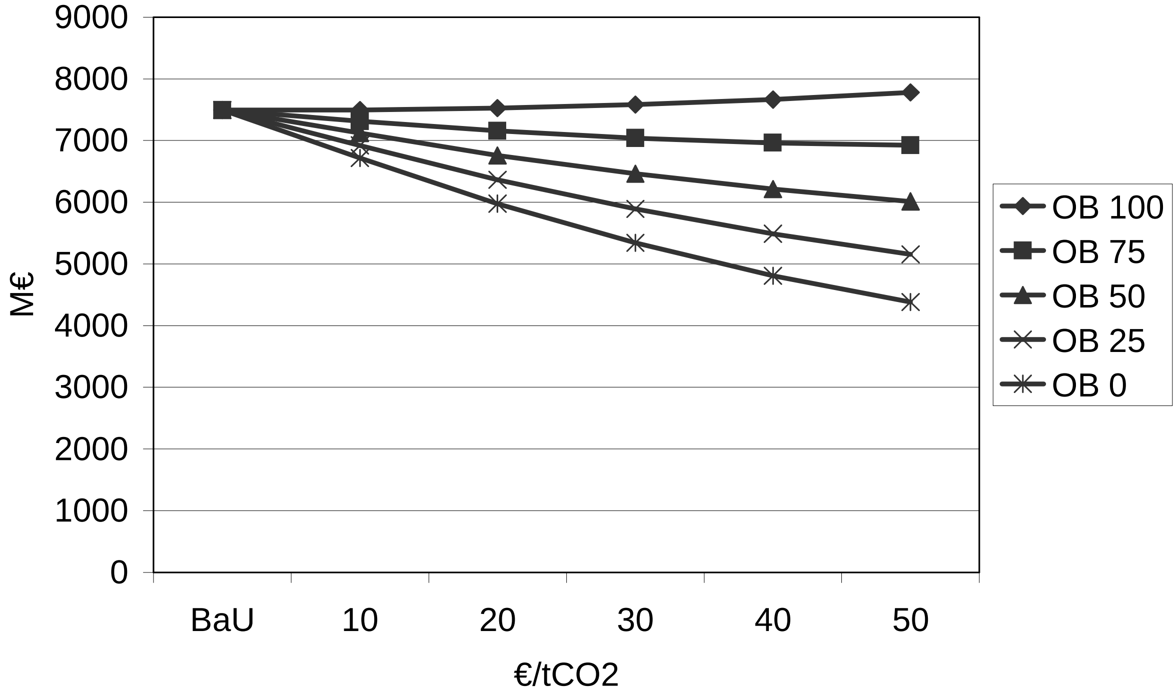

Figure 10: OB - EU27 EBITDA

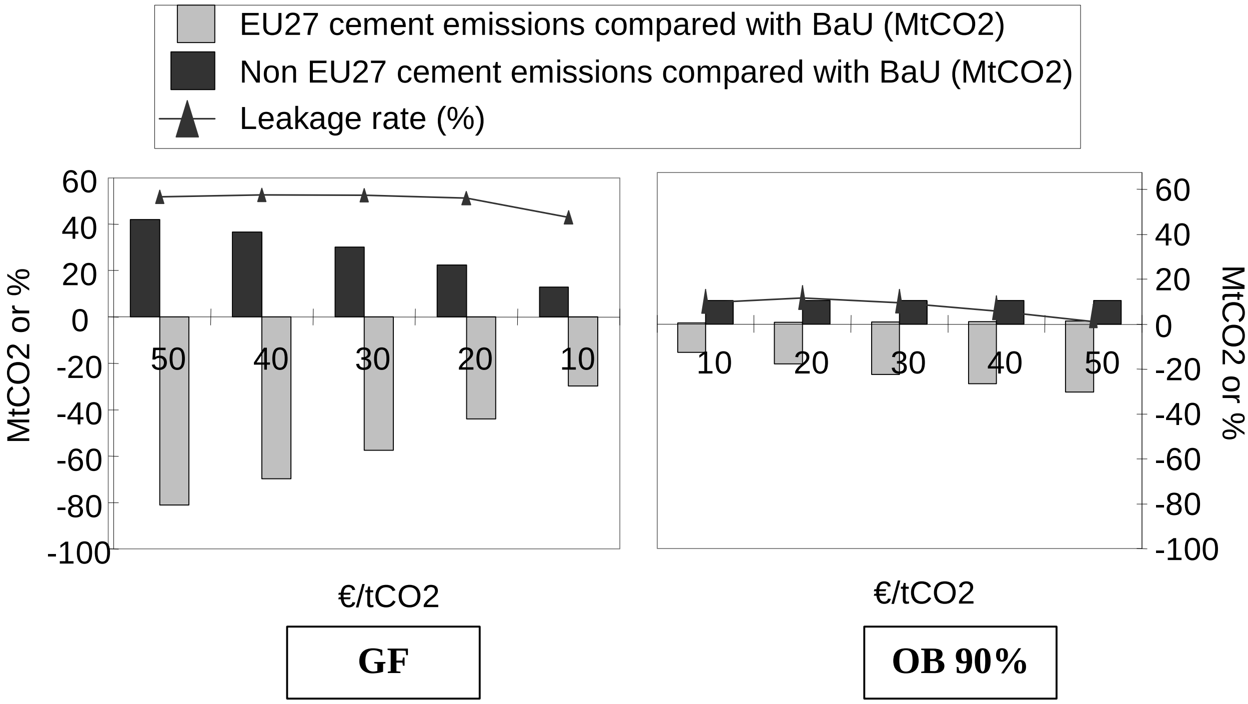

Figure 11: GF / OB 90% - EU27 emissions reduction

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